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SAFFLOWER, A POSSIBLE NEW OIL-SEED CROP FOR THE NORTHERN GREAT PLAINS AND THE FAR WESTERN STATES

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INTRODUCTION

Safflower (*Carthamus tinctorius* L., family Asteraceae, fig. 1) has been cultivated in India and Egypt for many years as an oilseed crop and as a source of a red dye obtained from the flowers. Its importance as a dye plant has declined greatly since the introduction of artificial dyestuffs, but it is the most important oilseed crop cultivated in the Bombay Presidency, where from 500,000 to 600,000 acres are grown annually. It is grown extensively also in the driest areas of the Deccan (India) for its oilseed, and to a small extent in China, Japan, Turkistan, and parts of Europe. In India the oil is used for edible purposes and as a soap oil. Because of its drying properties it has been found useful also as a paint and varnish oil and for waterproofing purposes. The oil cake remaining after the extraction of the oil is reported to possess value as a stock feed. However, on account of lack of definite information concerning the value of these products neither the oil nor the oil cake have entered the channels of trade in countries outside of India and Egypt.

GENERAL DESCRIPTION AND HABITS

Safflower is an annual, erect, glabrous herb, 1 to 3 feet high, branched at the top, with white or yellowish smooth, pithy stems

[1] Acknowledgment is made of the valuable cooperation of the following: Bauer Bros. Co., Springfield, Ohio, in the decortication tests with the seed; French Oil Mill & Machinery Co., Piqua, Ohio, in the crushing of the decorticated seed with a hydraulic press; V. D. Anderson Co., Cleveland, Ohio, and Imperial Meal Co., Minneapolis, Minn., in the crushing of the seed by means of the oil expeller, and Archer-Daniels-Midland Co., Minneapolis, Minn., in the solvent extraction of the seed. Acknowledgment is also made of the assistance of State experiment stations and numerous farmers in making growing tests of the crop and of numerous paint and varnish manufacturers who conducted tests with the oil.

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and branches. The leaves are ovate-oblong, distinctly or scarcely spiny-toothed. The flower heads are globular, one-half to 1½ inches in diameter, with yellow-orange or orange-red florets. The seed is smooth, obovoid, four-angled, white or cream-colored, and somewhat

FIGURE 1.—Flowering top of a typical safflower plant.

smaller than sunflower seed. There are two distinct varieties of the plant, namely, *typicus* and *inermis*. The former is spiny and the latter spineless. Plants that in the wild state are very spiny show a tendency to become spineless under cultivation. The spiny variety

is considered the best sort for oilseed production. The plants are exceedingly resistant to spring frosts and because of their long taproots withstand droughts well. The sturdy stems enable the plants to withstand wind and hail with little damage and to resist lodging.

COMMERCIAL IMPORTANCE

In the manufacture of paints, varnishes, linoleums, and allied products large quantities of drying oils are required. In the United States the principal oil used for this purpose is linseed oil, derived from flaxseed, of which in recent years not more than half the quantity required has been produced in this country. This has necessitated the annual importation of large quantities of flaxseed, most of which comes from Argentina. The need, therefore, of a supplementary crop to supply satisfactory drying oils is apparent. Safflower has been suggested as such a crop.

FIGURE 2.—An 80-acre field of safflower on dry land at Lambert, Mont.

For several years safflower has been grown experimentally in a number of the States of the northern Great Plains under both dry-land farming conditions (fig. 2) and under irrigation. Through the active interest and cooperation of growers in those sections the acreage, although scattered, has been gradually increased thus making sufficient seed available for expanded acreages if desirable. While there are but two distinct botanical varieties, numerous forms of the plant exist and tests are being conducted to determine which is the most desirable from the standpoint of yield of seed and oil. Through careful study the agronomic requirements of the crop and the technological processes related to handling the seed and the production of oil, as well as the application of the oil in commerce, have been determined.

SOIL AND CLIMATIC REQUIREMENTS

Safflower grows best in a light, deep soil, preferably clay loam or sandy loam. Heavy clay or gumbo and light sandy soils are less suitable. The presence of lime and humus is beneficial. Soils extremely rich in nitrogen which cause luxuriant growth with but few flowers are not desirable. Although the crop is considered to be fairly drought-resistant, considerable soil moisture is necessary during the germination of the seed and until the flowering period, after which less moisture is required. Continued cold and wet weather during germination of the seed and early growth of the crop retards its development. Excessive rain and humidity throughout the growing season are very detrimental, such conditions interfering apparently with the proper pollination of the flowers. Sunshine and warm weather from the budding stage through to maturity facilitate growth and insure proper development of the seed. During the early stages of growth the crop is very resistant to frost, but at the time of seed formation heavy frosts are damaging. However, if the crop is seeded at the proper time in the spring it should be well matured before the early fall frosts.

SELECTION AND PREPARATION OF LAND

Selection and proper preparation of the land are important for the success of the crop. Clean land of average texture and fertility, which is well drained, should be selected. Land cropped the previous season to corn, potatoes, sweetclover, or alfalfa is very desirable. Low ground where water is likely to remain after heavy rains should be avoided. The land should be plowed 7 or 8 inches deep in preparation for the crop; it should not be sown on shallow plowed land. Land that is badly infested with pigeon grass, quackgrass, wild sunflowers, or other weeds should not be used because weeds interfere greatly with the proper growth of the crop. If the land has been fall plowed it should be disked about 2 weeks previous to sowing the seed, and immediately before sowing it should be disked again and double-dragged in order to destroy any weeds that may have germinated. If the land is not fall-plowed it should be plowed in the spring at least 2 weeks before sowing time and then prepared as described.

SEEDING

The date of seeding depends upon the climatic conditions which prevail during the early spring. Since cold, wet weather is unfavorable to the germination of the seed and early growth of the crop, very early seeding is not recommended. In Minnesota, North Dakota, South Dakota, Nebraska, Montana, and other States having similar spring conditions, seeding should take place between April 10 and May 1, according as the season is early or late. The moisture of the soil should be such as to insure quick germination of the seed. The exact date of seeding, therefore, can best be determined by the individual grower. In the Northern States seeding should not take place as early as for wheat unless the season is well advanced.

When grown under irrigation, if there is insufficient moisture for germination at seeding time it should be irrigated up. Irrigation

shortly before and during the flowering period has been found very satisfactory in the tests that have been made in Montana and Idaho. Too frequent irrigation has been found to be detrimental to proper development of the plants.

The rate of seeding depends on the percentage of germination of the seed, and, since this is closely related to the weight of the seed per bushel, the following approximate rates are recommended:

Good hard seed weighing 40 to 48 pounds per bushel should be seeded at the rate of 50 to 60 pounds per acre.

Lighter seed weighing 35 to 39 pounds per bushel should be seeded at the rate of 65 to 75 pounds per acre.

Extremely light seed weighing 30 to 34 pounds per bushel should be seeded at the rate of 85 to 100 pounds per acre.

Since the rate of seeding has a direct bearing on the percentage stand of plants, which in turn is a determining factor in the yield of seed, it is important that these rates be followed in order to insure the maximum yield of seed. Only clean seed free from weed seeds should be sown.

Heavy seeding, although producing more plants per unit of area, tends to inhibit proper branching, thereby reducing the number of flower heads. If crowded the plants produce only 1 or 2 flower heads, usually of small size, whereas if they are from 4 to 5 inches apart they will frequently produce as many as 12 to 15 flower heads of uniformly large size. It is obvious, therefore, that too heavy seeding should be avoided. A good stand is one in which the flower or seed heads uniformly cover the field.

The best method of seeding is by means of the ordinary grain drill in 6-, 7-, or 8-inch drills. The drill should be set to drop the seed at the given rate per acre, which, with proper germination, will insure a full stand of plants from 4 to 5 inches apart in the row. The seed should be planted about 1½ to 2 inches deep, but where blowing of the soil is apt to occur a depth of 2½ inches is recommended. The plants should appear above ground in from 4 to 6 days, depending on the moisture in the soil and the prevailing temperature.

HARVESTING AND THRESHING

Under favorable conditions the crop matures in about 100 to 120 days. About 8 or 9 weeks after germination the plants stool and the golden-yellow or red blossoms begin to appear. When the plants are in full bloom from 4 to 12, or even more, flower heads are present on each stalk if the plants are not too crowded. Setting of the seed continues for about 4 or 5 weeks. When properly and fully matured, the plants will attain a height of 18 to 36 inches.

When practically all of the blooms have disappeared and the seed is hard and dry and can readily be separated by rubbing the seed head in the hand, the crop should be harvested. This may be done with a self-binder or with a combined harvester-thresher (combine). If the self-binder is used the crop should be shocked (fig. 3) and allowed to stand in the field until ready for threshing. On account of the hard seed coat, the grain is not greatly affected by rains or wet periods after maturity unless of prolonged duration. Neither is it subject to damage by birds. The seed does not shatter out during harvesting or shocking because of the firmness with which it is held

in the seed head. On account of the sturdiness of the stalks, which prevent lodging, and the resistance of the seed to shattering, the crop may be allowed to stand in the field without damage for 1 or 2 weeks or even longer before harvesting or threshing.

When the crop is sufficiently dry it may be threshed from the shock by means of the ordinary grain separator fitted as for wheat or barley. The cylinder teeth should be adjusted as for oats with only 1 or 2 rows of concave teeth to prevent breaking or hulling the seed. Since the seed is considerably lighter in weight than wheat, care should be taken to adjust the air properly so that none of the filled (hard) seeds will pass over into the straw. It is recommended that where possible the crop be threshed with the combine (fig. 4), now so generally used in certain sections of the small-grain belt. This method has been found very satisfactory and is more economical than other methods.

FIGURE 3.—Field of safflower in shock at Morris, Minn.

The seed from the thresher will contain particles of straw, chaff, weed seeds, and some light (unfilled) seeds. In order to remove these the seed should be passed through a fanning mill, which is available on practically every farm where small grain is grown. The cleaned seed should be stored in a dry place, preferably in bulk in a bin. If stored in bags considerable damage may result from mice. The weight of good, hard, clean seed averages from 42 to 48 pounds per bushel.

YIELD OF SEED AND FACTORS AFFECTING YIELD

The yield of safflower seed is influenced by the conditions under which the crop is grown and under dry-land farming conditions will vary as greatly as that of other small grains. When grown under irrigation so that the moisture supply can be controlled and with proper attention to other requirements considerably higher yields may be expected.

During the 9-year period from 1925 to 1933, inclusive, a total of 206 plantings were made by farmers and State experiment stations

in cooperation with the Department and at United States Department of Agriculture field stations in 15 States under dry-land farming on plots ranging in size from a small fraction of an acre to 80 acres. The majority of tests were conducted in the northern Great Plains region including Montana, North Dakota, South Dakota, Minnesota, Wyoming, and Nebraska. The others were made in Iowa, Illinois, Kansas, Oklahoma, Colorado, Texas, Oregon, Washington, and California. In addition to these, 25 plots from one-

FIGURE 4.—Harvesting and threshing safflower with power combine at Homestead, Mont.

quarter acre to 3 acres in size were grown under irrigation in Montana, Idaho, Utah, South Dakota, California, and Wyoming. The yields of these plantings are summarized in table 1.

TABLE 1.—*Safflower plantings and yields under dry-land and irrigation culture, 1925–33*

Group	Plantings		Yield per acre	Group	Plantings		Yield per acre
	Dry land [1]	Irrigation [2]			Dry land [1]	Irrigation [2]	
	Number	*Number*	*Bushels*		*Number*	*Number*	*Bushels*
1	17	--------	0 to 1	6	5	3	30 to 40
	32	--------	1 to 5	7	1	2	40 to 50
2	64	1	5 to 10	8	--------	8	50 to 60
3	42	1	10 to 15	9	--------	2	Over 60
4	27	2	15 to 20				
5	18	6	20 to 30	Total	206	25	--------

[1] The acreages of these plantings were: 63, up to and including ¼ acre; 70, ¼ to 1 acre; 48, 1 to 5 acres; 25, over 5 acres.
[2] The acreages of these plantings were: 22, ¼ to 1 acre; 3, 1 to 5 acres.

Of the 206 dry-land plantings, 49, or approximately 24 percent, were reported as total or partial failures with yields of less than 5 bushels of seed per acre, 17 of the plots yielding less than 1 bushel per acre. The remaining 157 plantings yielded from 5 to 10 bushels per acre in 64 tests, representing approximately 31 percent of the total plantings, while 92 plantings, corresponding to approximately

45 percent of the total, gave yields from 10 to 40 bushels per acre. A single test gave a yield of over 40 bushels per acre.

Under dry-land farming conditions numerous factors contributed to the success or failure of the crop. Listed in the order of their frequency the principal factors reported as causes of low yields were as follows: Protracted drought frequently accompanied by soil blowing, poor stand of plants due to soil conditions unfavorable for germination, wrong type of land, shallow plowing, and improper preparation of the seed bed to eliminate weed growth. Other conditions reported to have been occasionally responsible for or to have contributed to low yields are improper seeding rate, late date of seeding, cold, wet seasons with low germination and poor stands, harvesting before fully mature, and careless harvesting or combining of the crop. Frequently a combination of several of the factors was responsible for low yields of seed.

A careful analysis of the reports received from the numerous growers during the 9-year period showed that excessive and protracted drought was the most frequent cause of failure in the 49 plantings in group 1 with yields of less than 5 bushels of seed per acre. In three cases failure was ascribed to heavy rains which caused flooding of the fields. In group 2, with yields of 5 to 10 bushels per acre, 51 of the 64 tests were reported as having been grown under drought conditions. Seven were grown in sections with extremely cold and wet seasons, causing low germination and poor pollination. The remaining six plots in this group were grown on either heavy gumbo soil, which is unsuited for the crop, or on very weedy land followed by harvest before maturity, resulting in the production of light, unfilled seeds. Included in groups 3 and 4, comprising 69 plantings, with yields of 10 to 20 bushels per acre, were 60 plots grown under drought conditions, 5 during cold and excessively wet seasons, and 4 under favorable seasonal conditions. The 23 plantings in groups 5 and 6, with yields between 20 and 40 bushels per acre, were all reported as having been grown under favorable or very favorable seasonal conditions on good, properly prepared land with a full stand of plants. The single planting in group 7, which yielded over 40 bushels per acre, was grown in the San Joaquin Valley in California under winter dry-land farming conditions.

When the crop is grown under irrigation the principal factors which are apt to affect the yield of seed are too frequent irrigation, low germination due to lack of spring soil moisture, excessive weed growth frequently occurring in some irrigated sections, and unsuitable types of soil. In groups 2 and 3 with yields between 5 and 15 bushels per acre, both tests suffered from too frequent irrigation causing many plants to die. The 2 plantings in group 4 which produced from 15 to 20 bushels per acre were grown on alkali and heavy gumbo soil, respectively, both of which are unsuitable. The yields of the 6 plantings in group 5 were affected by improper irrigation, improper soil or late seeding, with harvesting too early to permit full maturing of the seed. Too frequent irrigation of the 3 plots in group 6 appears to have been responsible for failure to obtain higher yields of seed. In group 7 the 2 plantings, although yielding between 40 and 50 bushels per acre, were affected by some reduction in stand due to lack of spring moisture. The 8 plantings recorded in group

8 with yields of 50 to 60 bushels per acre and the 2 plantings in group 9 which yielded over 60 bushels per acre were grown under good conditions of irrigation on good clean land.

From the results obtained on these numerous test plots it appears that under exceptionally favorable dry-land farming conditions in the northern Great Plains on suitable soils and with good farming practice yields from 20 to 30 bushels and even more of seed per acre may be obtained. Under the less favorable conditions, which usually may be expected, yields would be correspondingly less. With full compliance on the part of growers with the directions for growing the crop, especially as regards rate of seeding and depths of plowing, higher yields may be expected than following noncompliance with directions. When grown under irrigation on suitable soils with good farming practice the crop may yield as much as 50 to 65 bushels of seed per acre.

CRUSHING AND EXTRACTING THE SEED

Safflower seed of good quality that weighs from 42 to 48 pounds per bushel contains from 22 to 28 percent of oil. The oil can be extracted from either the whole or the decorticated seed by the usual commercial methods employed in obtaining fatty oils, namely, hydraulic pressure, expeller, and solvents. When the whole seed is to be extracted with a hydraulic press or an expeller it is ground, flaked, and tempered with steam before crushing, but if the solvent method is to be used tempering is not necessary and grinding only, if properly done, may be sufficient.

DECORTICATION OF THE SEED

A commercial decorticating test on approximately 1½ tons of seed was made with a modified cottonseed hulling and separating machine. With this equipment 43 percent of meats and 57 percent of hulls were obtained, containing 44 and 8.2 percent of oil, respectively. It was found that the operator, by proper previous grinding of the seed and proper adjustment of the sieves and aspirator, can control the proportion of hulls remaining with the meats. This is important because a definite proportion of fiber must be present to assure maximum efficiency in the performance of the hydraulic press and the expeller.

CRUSHING OF THE DECORTICATED SEED

One-fourth of a ton of meats produced in this decorticating test was crushed by means of an experimental hydraulic cage press. The meats were first passed over steel rolls and flaked the same way as flaxseed, and the flaked meats were then cooked with steam in a tempering apparatus or stack cooker at a temperature of 200° to 218° F. with the addition of sufficient water to make the mass satisfactory for crushing. The press was operated in the same way as in commercial practice. Approximately 38 percent of oil was obtained from the material and the press cake contained slightly over 6 percent of oil.

One-third of a ton of meats from the same lot was crushed by means of an experimental oil expeller. This material was not flaked,

but before it was passed through the expeller it was treated in a tempering apparatus where moisture was added and the temperature of the mass brought to 198° F. Under these conditions a yield of slightly over 38 percent of oil was obtained, with 6 percent of oil left in the press cake.

CRUSHING OF WHOLE SEED

In a later test, 2,000 pounds of good clean seed containing 25 percent of oil was crushed in a commercial expeller unit. The seed was first ground medium fine in a hammer mill and then passed through the tempering box of the expeller where water was added and the mass subjected to 50 pounds of steam pressure before crushing in the expeller. By this method 18.75 percent of the total oil in the seed was recovered. The shrinkage was 5.6 percent which was due to loss of moisture, loss of some seed during grinding, and loss of material and oil in various parts of the expeller. The press cake contained approximately 6 percent of oil.

In the handling of a comparatively small quantity of seed it is evident that maximum efficiency of expeller operation is not attainable. Operating continuously on large quantities of seed with an oil content of 25 to 27 percent under commercial conditions of expeller operation and with careful control of grinding and preparation of the seed it is estimated that a yield of 20 to 22 percent of oil can be obtained by this method.

SOLVENT EXTRACTION OF THE OIL

Recently the oil was extracted from 48 tons of seed with a solvent by a firm in the Middle West to obtain information on commercial solvent extraction of the oil, and enough oil and meal for study of possible demand and value of the seed.

The seed was coarsely ground and the oil extracted with hexane, a low-boiling fraction of gasoline in a commercial continuous solvent extraction plant of new design. The seed used in the test was grown under irrigation in northeastern Montana and represented a mixed lot produced by a score or more of growers. In spite of the fact that the seed was only of medium quality, the run from the standpoint of plant operation was considered successful. The oil was readily sold to paint and varnish manufacturers at a price midway between the prevailing prices of linseed and soybean oils. It was stated that, for certain special uses, the oil would bring the same price as linseed oil. The firm that made the extraction reported that the oil was light in color, clarified easily, and possessed a low acid value, making it valuable from many standpoints, especially in varnish making where nonyellowing is an important factor. The meal which was returned to the growers of the seed for stock feeding was suggested as of possible value in the field of plastics where sunflower and soybean meals have shown promise.

USES OF THE OIL, PRESS CAKE, AND MEAL

Extensive laboratory tests with the oil followed by tests made in manufacturing plants indicate that it is a valuable raw material

for use in the paint, varnish, and allied industries. It possesses good drying properties, and paints made with the oil show satisfactory durability and weather resistance. It has been found to have distinct merits in white paints and white enamels where nonafter-yellowing and permanent whiteness are desired. Varnishes made with the oil behaved normally and possessed good color, body, water resistance, and gloss. It lends itself satisfactorily to heat treatment, refining, and bleaching. When the oil is heated in earthenware vessels for 2½ hours at a temperature between 307° and 310° C. it polymerizes into a stiff yet very resilient mass which is soluble in turpentine and other solvents. This product may be useful as a base for the manufacture of linoleum. Numerous manufacturers have reported favorably regarding the use of the oil in paints and varnishes and some have indicated a desire to purchase the oil in quantity for use in their products.

Several feeding experiments in the United States and Germany indicate that safflower seed press cake or meal may be used as a protein-rich concentrate much the same as cottonseed meal, linseed meal, or soybean meal in feeding livestock. When it is fed in such quantities as are necessary to supply protein adequately, it appears to have no undesirable effects upon the animals or the flavor of their products. The decorticated press cake has about the same protein content as cottonseed meal, and the press cake made from the whole seed has about the same protein content as coconut meal, as table 2 indicates. The meal, made from the seeds from which the fat has been extracted by solvents, has about the same protein content as wheat bran. The products made from the whole seed have a very much higher crude-fiber content than any similar products from oil-bearing seeds which are commonly used. In fact, they rank lower than most straws in this respect. Therefore, products from the whole seed should be fed principally to cattle and sheep, as they can utilize such fibrous feeds better than other livestock. If a concentrated ration is desired, the whole seed cake or meal should not exceed one-fourth to one-third of the grain ration. In feeding experiments conducted separately by two German investigators,[2] feeding about 4.5 pounds of the press cake per head daily to dairy cows reduced the butterfat content of the milk slightly.

A limited feeding test [3] was made by the Bureau of Dairy Industry at Beltsville, Md., to determine whether safflower oil meal (ground press cake) could be used in a dairy ration without affecting the quality of the milk. A grain ration consisting of 33⅓ percent safflower oil meal from the whole seed was readily consumed by dairy cows without noticeable effect on the flavor or odor of the milk produced, and it was stated that it should be entirely satisfactory as a feed for cows.

[2] Chemical Abstracts, vol. 25, pp. 546 and 1297.
[3] Letter from T. E. Woodward, dated Jan. 19, 1929.

TABLE 2.—*Composition of safflower press cake and meal*

Materials	Components					
	Moisture	Ash	Protein	Crude fiber	Nitrogen-free extract (starches and sugar)	Ether extract (fat)
Press cake:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Decorticated seed	8.97	8.18	38.06	20.96	17.06	6.77
Whole seed	4.10	2.90	19.20	42.60	25.40	5.80
Meal (by solvent): Whole seed	7.91	3.02	16.62	45.64	24.96	1.85

In a more extensive test conducted by the Department of Dairy Husbandry, North Dakota Experiment Station, Fargo, N. Dak., using the oil meal from the whole seed, it was reported [4] that it is a fairly good substitute for linseed meal for milk cows and did not appear to be either constipating or laxative.

The seed and oil cake or meal are reported by some investigators to be excellent sheep and poultry feeds.

DISEASES AND INSECT PESTS

Safflower appears to be comparatively free from diseases and to suffer little from insect pests in those localities to which it is best adapted. In India where the crop is grown extensively the wilt disease of safflower was observed for the first time at Pusa in 1920. It is stated by Joshi [5] that the disease is of most common occurrence in years of abundant rainfall with low temperature and high humidity. The disease is caused by a fungus which attacks the stem of the plants, causing a yellowing of the leaves and quick wilting of the plants. This fungus is said to attack a variety of other crops and weeds. The most practical method of controlling the disease is to collect and destroy the infected plants and then plow the field to a depth of over 6 inches which destroys the sclerotia.

During the period the crop has been under observation in the United State a disease with apparently the same symptoms has been reported from Virginia, Indiana, and South Dakota.

It is noteworthy that the outbreaks of the disease were observed only during seasons of excessive rainfall and high humidity. Specimens of the diseased plants obtained from Indiana were found by R. J. Haskell, senior plant pathologist, Extension Service, United States Department of Agriculture, to possess symptoms corresponding closely to those of anthracnose (*Gloesporium carthami* Hori and Hem.) which has been described in Japan. Two other fungi, which have been reported as causing diseases of this host, *Septoria carthami* Muras. and *Macrosporium* sp., were also found. The general effect on the plants corresponds closely with the wilt disease reported by Joshi.

While the crop has been found to be reasonably free from insect attacks, some cutworm damage has been reported by growers during

[4] Letter from J. R. Dice, Dec. 8, 1932.

[5] JOSHI, S. D. THE WILT DISEASE OF SAFFLOWER. Indian Dept. Agr. Mem., Bot. Ser. 13 (2): 39–46, illus. 1924.

seasons favorable to this pest. A small plot in Oklahoma is reported to have been ruined by beetles. Grasshoppers, which are a serious pest in the northern Great Plains in some years, are reported by most growers to have caused only slight damage to safflower in localities where small grain crops were completely destroyed.

RETURNS TO GROWER

The cash returns to the grower of safflower must necessarily depend on the value of the oil and the press cake or meal obtained from the seed as well as on the yield of seed per acre. With commercial crushing practices normal safflower seed weighing 45 pounds to the bushel will yield about 9 pounds of oil and 36 pounds of cake, whereas flaxseed weighing 56 pounds per bushel yields approximately 18.5 pounds of oil and 37.5 pounds of cake. Seed of the same quality, if extracted commercially by solvents instead of by crushing, will yield 10.8 pounds of oil and 34.2 pounds of meal.

On the basis of observations and practical tests in the northern Great Plains, it is estimated that under comparable conditions when common spring wheat yields 20 bushels and flax 8 bushels per acre, safflower should yield about 20 bushels. At 93 cents a bushel for wheat and $1.60 for flax, the prices quoted to farmers in northeastern South Dakota in February 1935, it would be necessary, then, for safflower to bring the farmer 93 cents a bushel to equal the return from wheat and 64 cents to equal that of flax.

SUMMARY

Safflower is suggested as a new dry land and irrigation crop for the northern Great Plains for the production of a drying oil to supplement the supply in the United States of other domestic drying oils, the production of which does not equal the demand. It also seems well adapted to winter dry-land farming in certain sections of the far Western States.

Experiments with the crop show that it fits well into the agriculture of the northern Great Plains and requires no change in either methods or machinery now in use for the production of small grains.

The crop is exceedingly resistant to spring frosts, withstands drought well, suffers less damage from wind and hail than the small grains, does not lodge, does not shatter after maturity, does not discolor, and is an ideal crop for "combining."

It is noticeably free from diseases if grown under favorable conditions and suffers little damage from insects in the sections where most of the trial plantings have been made. Maximum yields of about 40 bushels of seed per acre have been obtained under dry-land farming in the northern Great Plains with unusually favorable soil, climatic, and cultural conditions. With similar conditions under irrigation yields of 50 to 65 bushels of seed per acre have been obtained. Average yields have been about 10 bushels in dry-land tests and about 38 under irrigation.

The seed can be crushed or extracted by the usual methods of producing oil from oilseeds.

The oil has been found to be a valuable raw material for use in the paint, varnish, and allied industries. It is especially useful in the

manufacture of white paints and white enamels where permanent whiteness is desired. Paints made with the oil show satisfactory durability and weather resistance.

Limited feeding tests with the press cake or meal indicate that it possesses value as a feed for dairy cattle. Its usefulness as a sheep and poultry feed is also indicated.

Manufacturers have expressed a desire to purchase the oil for use in their products and oil crushers have indicated that they will be in the market for the seed when available in large quantities.

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